Greenhouse Vegetable Production in Saskatchewan

Production and Economic Information

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Foreword

Saskatchewan Agriculture and Food has received many requests for information regarding the production of vegetables in a greenhouse environment. This publication was prepared to help answer some of the basic questions about greenhouse vegetable production. An informal survey of Saskatchewan greenhouse vegetable producers was undertaken in December 1998 and January 1999. A summary of average costs of production calculated from the survey results is included in this publication.

The objective of this publication is to provide basic production information and cost of production information for establishing a greenhouse vegetable enterprise. The reader is cautioned that some of the assumptions, although considered complete and accurate at time of publication, may prove inaccurate, as more current information becomes available. The prices used are representative of the market conditions, compiled from a variety of sources at the time of publication and are not meant to predict the future. Producers are cautioned that the information in this publication will require interpretation and adjustment for their own individual situation.

This publication was written by Martin Ferguson and Glen Sweetman of Saskatchewan Agriculture and Food. The assistance of the greenhouse operators who provided information for the survey is greatly appreciated.

This publication and other Saskatchewan Agriculture and Food publications are on the Saskatchewan Agriculture and Food website at: http://www.agr.gov.sk.ca

For further information contact:

Glen Sweetman
Provincial Specialist
Greenhouse and Nursery Crops
Crop Development Section
Telephone: 306-787-6606

or

Mike Pylypchuk
Provincial Specialist
Production Economics
Economics and Farm Management Section
Telephone: 306-787-5963

Sustainable Production Branch
Saskatchewan Agriculture and Food
Room 125, 3085 Albert Street
Regina, Saskatchewan
S4S 0B1

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Introduction

Greenhouse structures were developed for crop production during periods when growing outdoors was not feasible. Greenhouses were designed to optimize the penetration of incoming solar radiation. Initially control of temperature, relative humidity, carbon dioxide and air movement was primitive. As plant growing practices improved, better control of the greenhouse environment became essential. In highly specialized crop production all conditions must be controlled uniformly in every part of the greenhouse for maximum net returns.

The greenhouse industry in Saskatchewan is in its infancy. There has been increasing interest in greenhouse production. It is important to keep in mind that markets and demand must be the reason to produce a product. Study markets before you get into production so you are producing a product that the consumer needs and wants. Once you have done a market study and have determined what products you can sell, then you can focus on the production of those products.

The objective of this publication is to provide basic production information and cost of production information for establishing a greenhouse vegetable enterprise. The reader is cautioned that some of the assumptions, although considered complete and accurate at time of publication, may prove inaccurate, as more current information becomes available. The information in this publication will need to be customized to suit the individual's need.

Marketing

Marketing will probably be your number one consideration when deciding whether or not to go into a vegetable greenhouse operation. You should do a market survey and follow that with the preparation of a business plan. It would probably be a good idea to visit several greenhouse operators in an area that is not near your proposed location. Greenhouse operators in your local area may not be willing to share their information with you because you may eventually be their competition.

You may have several unique segments in your potential market. It is important to identify these segments and develop separate marketing plans where necessary. An important consideration in the greenhouse business is "can you sell the greenhouse production at a profit?" Returns and costs of production must be monitored to ensure that profit is achieved in order to stay in production.

The weather conditions and crop yields in the southern United States have an impact on the market price of vegetables in Saskatchewan. Field grown tomatoes in the United States and Mexico impact Canadian tomato prices. A good tomato crop in Florida will mean a poor price here and vice versa. The Texas crop has an impact on our cucumber prices. A poor cucumber crop in Texas means a good cucumber price in Saskatchewan and vice versa.

Retail Outlet at the Greenhouse

Setting up a retail outlet at your greenhouse is feasible if you are located close to a well-traveled highway. One of the benefits of a retail outlet on site is it allows other tasks to be done while the outlet is open for business.

Some considerations if you are setting up a retail outlet are:

- Liability insurance should be purchased for your customers.
- A parking area, good signage and washroom facilities will be required to accommodate customers.
- Consider promotional activities that will reach potential customers.
- Develop a retail environment that appeals to your buyers.
- Present high quality produce.
- Use displays to promote sales.
- Use labels to differentiate your product from others.
- Be open for business at convenient hours.
- Be open for business at the same hours each day.
- Provide product information such as recipes and cooking instructions.
- Be prepared to work seven days a week.

There are three very important things when building a retail outlet: **location, location, and location.**

Pricing your products for your retail outlet is an important consideration. You must cover your cost of production and make a profit in order to stay in business. Your minimum price should cover all costs including production costs, marketing, overhead, the costs of unsold production, the cost of unpaid accounts and a return to the owner's capital and management contributions. Competitors' prices are a consideration but production costs must be taken into consideration. You cannot sell below your cost of production in the long term if you want to stay in business.

Providing good customer service may help to expand your business. Consider doing a survey of your customers to see what their needs and wants are. Strive to meet your customers needs with well-trained and friendly staff.

Selling Through Farmers' Markets

If you are selling at a farmers' market, you must harvest, clean, package and transport your products to the market at a specific time. At the farmers market there could be many producers offering similar products. You should be prepared to have unsold production.

Strategies for selling at farmers' markets are:

- Keep the same location.
- Sell only quality products.
- Use labels to differentiate your product from others.
- Use displays to promote sales.

Selling to Wholesalers

As a general rule wholesale prices will be one-half to two-thirds of the retail market price.

The following strategies will assist you in dealing with wholesalers.

- Make business calls to wholesalers to keep them up-to-date on your production plans and your current

prices, and to get information on their current prices and market trends.
- Provide products in the containers liked by the wholesalers.
- Be prepared to provide specific products to different wholesalers to respond to niche markets.
- Prepare a written list of your products and leave copies with wholesalers.

Most of the larger wholesalers require a minimum quantity that is difficult for smaller producers to reach on their own. It is also important to them to have a constant and reliable supply. In short, this is not the best price that you will receive for your product, although you will likely be able to move large quantities of your product. If you are set up to meet the needs of a wholesaler market, it can be profitable.

Advertising Your Products

Spending a small amount of money on advertising may be a good investment. The following strategies may benefit your operation.

- Business cards are a relatively inexpensive form of advertising.
- An identification sticker on your products tells your customers who you are and how to get on touch with you.
- Make your product different in the eyes of the consumer. If, for example, you do not use herbicides in your production, you should let your customers know, and that may differentiate your production from your competitors.

Regulations

Some of the regulations that should be considered are:

- **municipal zoning** - provincial and municipal sign laws. Contact rural municipal office and/or town or city office.
- **health regulations**. All businesses must comply with the *Public Health Act*. Contact the health inspector in your district.
- **labour regulations**. Contact the Labour Standards Branch; toll free 1-800-667-1783.
- **occupational health and safety**. All businesses must abide by the *Occupational and Safety Act*. For further information contact the Occupational Health and Safety Division at 1-800-567-7233 in Regina or 1-800-667-5023 in Saskatoon.
- **workers' compensation and Revenue Canada payroll deductions for employees**. For more information contact the Workers' Compensation Board and/or Revenue Canada office closest to you. They are listed in the blue pages of your telephone directory.

Saskatchewan Economic and Co-operative Development, Business Services Improvement Branch, has prepared an information bulletin titled "Information for Greenhouse Operations" that provides an outline of potential licence, permit or registration requirements to be considered in the establishment of a greenhouse operation in Saskatchewan. Contact the branch office in Regina for a copy of this information.

Production Management Issues

There are many production management issues each of which are important in their own right. If any of the following issues are not addressed, then they could be a limiting

factor in your greenhouse production program.

Size of the Greenhouse Relative to the Market

Sizing the greenhouse to the market is one of the most important decisions you will make. If you have already done an analysis of your projected market, then sizing the greenhouse will be one step closer to completion. On the basis of your market analysis you will have to decide whether you are going to build for the exact size of your projected market, or whether you build slightly larger assuming that you will increase your market share. You may decide to build for the projected market, but in your plans, allow for a future expansion. It is always easier and cheaper to plan for future expansion at the beginning than trying to accommodate changes later.

Heating System

There are several issues to consider when deciding on a heating system for your greenhouse. The cost of the heating system is usually the largest capital outlay, with the only exception being the cost of bringing gas lines and/or electrical lines onto the property. The heating system must be safe and non-polluting. It is very important that it is able to provide adequate and consistent temperatures. It must meet all safety and building regulations.

There are three options when deciding on a heating system for your greenhouse.

1. Radiant heating system

   In a radiant heating system, heat is provided in the form of steam or hot water from a centrally located boiler. Steam or hot water is piped to the greenhouse from the boiler. In the greenhouse, heating lines with metal fins are often located near the ground because heat rises. Natural gas, propane, coal or bales can be used as a fuel source. Be sure to check the regulations regarding the distance from the burner to the nearest building.

2. Forced air heating system

   A forced air heating system with individual furnaces in each greenhouse is the second option. Forced air heat is often used with double polyethylene greenhouses. The main benefit of a forced air system is the economical installation.

   Plastic tubes are often used to deliver heat the full length of the greenhouse. On a 100-foot greenhouse it is common to use two 24-inch tubes. For the first 33 feet nearest the furnace there will not be any holes in the plastic air tubes. For the next 33 feet there will be one-inch holes in the tubing to let hot air out. For the last 33 feet there will be two-inch holes in the plastic air delivery tubing. The air inlet at the furnace will draw air from the far end of the greenhouse to circulate the hot air.

3. A combination of central and forced air heating systems

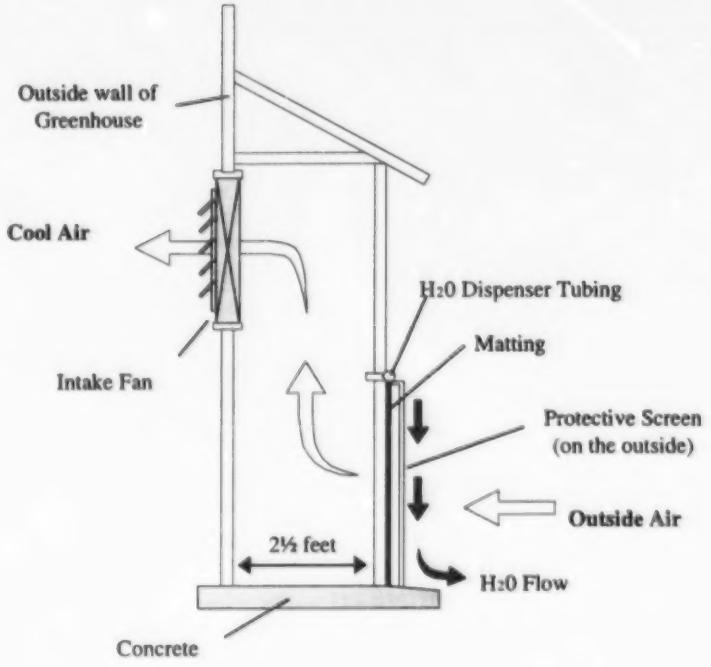
Cooling and Ventilation System

Saskatchewan summer temperatures are more than adequate to cause extreme temperatures within the greenhouse. Temperatures above 78 degrees F will cause plants to shut down internal processes. Proper ventilation is the key factor in controlling temperatures and relative

humidity, while providing CO_2 enrichment for good crop development.

There are two basic systems of ventilation, the natural and mechanical. Natural ventilation is the method of lowering the air temperature by wind or the natural exchange of hotter inside air with cooler outside air. This is done through roof and side-wall vents aided by naturally occurring breezes. Greenhouse design and location is very important to ensure that this method provides effective cooling.

Figure 1: Example Homemade Greenhouse Cooling System



Ventilation, the mechanical method of lowering the air temperature, is accomplished by drawing cooler outside air into the greenhouse. A forced cooling system uses large capacity low speed exhaust fans and inlet vents. The recommended air change capacity is 1.5 times the greenhouse air volume exchange per minute. For example, if the greenhouse volume is 30,000 cubic feet, then you should move 45,000 cubic feet of air per minute.

NOTE: It is important to remember that improper screening can reduce air exchange within the greenhouse thus causing major problems.

Air cooling systems are important because in the middle of summer you may be bringing in air that is 30 degrees Celsius or higher in temperature. In order to cool the greenhouse, it may be beneficial to have an evaporative cooling system installed at the vent opening. The air is drawn through continuously wet fibrous pads. This system is often referred to as fan and pad cooling.

Two alternate cooling systems are:

1. Special porous thermal curtains can be used to reduce the amount of solar radiation.

2. High pressure misting systems can be installed throughout the greenhouse.

A homemade cooling system can be attached to the end wall of the greenhouse. It can be built on a concrete pad. The use of treated lumber and plywood is recommended. The cooling system pictured above runs slightly less than the width of the greenhouse. The matting material is purchased in a four-foot-wide roll. (A

commercial pad product is available through greenhouse supply companies. Some local growers are using Curlex blankets as a substitute. Curlex blankets are used for land reclamation. Layers of these blankets may be required to achieve the desired effect.) A water dispensing tube runs along the top of the matting. Sprayer nozzles spaced uniformly along the water tube can be used to keep the matting wet. When the greenhouse-ventilating fan is operating, outside air will be drawn through the wet matting. The evaporation of the water from the matting cools the incoming air and lowers the greenhouse temperature.

Cost of a Homemade Fan and Pad Cooling System

A 28-foot-long fan and pad cooling system built on the end of a 30-foot-wide greenhouse as shown in Figure 1 would cost approximately $554.00 without the concrete floor. The following cost estimate assumes a lean-to 30 feet by 2.5 feet and eight feet high and 2x4's on 24-inch centres.

A concrete floor for the cooling system lean-to is optional and would cost approximately $100.00.

18 treated 2"x4"x8' @ $3.99 =	$67.83
10 treated 2"x4"x10' @$4.99 =	$19.96
13 treated 4'x8'x½" plywood @ $29.99 =	$359.88
Nails and miscellaneous	$20.00
Matting, 4 feet by 30 feet	$50.00
Total before taxes	$517.67
PST	$36.24
Total (assumes GST refunded)	$553.91

There are two advantages of using a lean-to cooler system. The matting area is easy to close off for winter by covering the hole on the inside of the matting with plywood. The cooler lean-to helps to insulate the greenhouse wall in winter.

Humidity Control

It is desirable to have a vapor pressure deficit. In other words you want slightly less humidity in the air than on the surface of the plants. At 20 degrees C the desirable humidity is approximately 65%. At 34 degrees C the desirable humidity is approximately 85%.

A large fan with tube running along the top of the greenhouse is useful for heating and venting in the morning to remove excess humidity. Dew or water on the leaves provides the ideal growing conditions for diseases and should be avoided whenever possible. Greenhouse roof design can also help reduce water droplets "raining" on the crop.

Stand-by Electrical Generator

Some greenhouse operators view a stand-by electrical generator as a requirement to run the heating, ventilating and cooling systems in the event of a power failure. The cost of a generator should be compared with the cost of losing a crop during a power failure.

Irrigation System

An irrigation system provides water to the growing plants at the right time and in the proper amounts.

Water Quality

Good water quality is one of the most important factors in growing quality greenhouse crops, yet it is often taken for granted and rarely analyzed. There are many factors that determine water quality. Among the most important are soluble salts, alkalinity, and the sodium adsorption ratio; but there are several other factors to consider, such as whether hard water salts such as calcium and magnesium are present, or whether there are heavy metals or individual toxic ions. In order to determine this, water must be tested at a laboratory that is equipped to test water for irrigation purposes.

Poor quality water can be responsible for slow growth and poor quality of the crop, or, if the water is very poor quality, it can result in gradual death of the plants. High soluble salts can directly injure roots, interfering with water and nutrient uptake. Salts can accumulate in plant leaf margins, causing burning of the edges. Water with high alkalinity can adversely affect the pH of the growing medium, interfering with nutrient uptake and causing nutrient deficiencies, which reduce growth, and may make some plants non-saleable.

Before setting up a greenhouse it is important to choose a site with suitable water quality. It may be easier and cheaper to locate the greenhouse at a site that has good water quality than spend a lot of money on water treatment in the future.

Water Testing

Water quality fluctuates throughout the year. It is recommended to test the water at least four times a year; more often if new wells are being used. A laboratory test, recommended at least once a year, will cost around $45 to $60. The water should be sent to a laboratory prepared to analyze the water for irrigation suitability (as opposed to human consumption). In Saskatchewan, Enviro-Test Laboratories, Saskatoon (1-800-667-7645) can provide these services. Some growers also use other laboratories in Canada and the USA. When collecting water for samples, allow the water to run for 20 minutes, then collect in a plastic bottle. The bottle should be completely filled and should not have a metallic lid.

Meters to test pH and salinity EC (conductivity) are available from greenhouse supply companies. It is very important to check the batteries and change them regularly as a small change in the voltage drop will have a large impact on the readings. EC and pH meters indicate the total impurities in the water, but do not indicate the type of impurities.

Water Treatment

There are several methods of treating water for use in a greenhouse.

Reverse osmosis units have a membrane, which allows only water to pass through, thereby leaving dissolved salts and solids behind, along with a certain amount of wastewater. These units are costly, but are one of the most widely used methods for purifying greenhouse water.

De-ionizers use specialized exchange resins to trap dissolved salts and replace them with hydrogen and hydroxyl ions, constituents of pure water. The exchange resins must be periodically replaced or flushed with acids or alkalis.

Filtration systems utilizing sand, cellulose or ceramic sieves are also used to some extent to remove undesirable minerals.

Acidification involves the use of acids, usually nitric or phosphoric, to reduce alkalinity. To reduce a bicarbonate level from 150 to 50 milligram per litre would require approximately 13.6 millilitre of nitric acid (62%) per1000 litres water, or 16.8 millilitre of phosphoric acid (75%) per 1000 litre water. A pH meter should be used to check the final pH of the water, and a laboratory test would be recommended before use.

Ultraviolet light is used to kill harmful organisms, but is not too effective unless the water is relatively clear. If water is turbid, filtration may be necessary beforehand.

Heat treatments (to about 60 degrees C) are used to kill disease organisms. Some precipitation of iron and calcium may occur.

Distillation is rarely practical because of the cost of operation.

For more information on water quality see the Saskatchewan Agriculture and Food farmfact "Water Quality in Greenhouses."

Water Delivery System

Water tanks should be dark or painted black to reduce algae growth.

Usually ¾-inch water lines can be used to deliver water throughout the greenhouse. Water emitters can be used to meter out water onto the growing media near the plants. There should be filters on the water lines to remove foreign material so the emitters do not plug. The filters should be cleaned every two months or as necessary.

Fertilizer Delivery System

The fertilizer tanks will usually be inside the greenhouse or header house so the fertilizer temperature will be close to the air temperature. Fertilizer injectors can be used to inject various fertilizer blends into the water lines for delivery to the plants.

Certain fertilizers should not be mixed together in one tank; therefore, separate tanks may be required. While certain chemicals cannot be mixed together in a tank, it is a standard practice to have them injected into irrigation lines at the same time.

Lighting System

Lighting is one of the most important factors for greenhouse production. Light provides the energy to convert carbon dioxide and water into carbohydrates within plants (photosynthesis). During the winter, light may be the limiting factor for greenhouse production. Reduced production can occur in the summer months if cloudy conditions persist for an extended period of time.

CO_2 Emitter System

During the process of photosynthesis plants absorb carbon dioxide from the air to produce carbohydrates necessary for plant growth. As a consequence of plant growth, CO_2 levels in the greenhouse could drop especially during periods when little air is exchanged with the outside. Adding CO_2 up to ambient levels (340 PPM) during spring and fall should be considered. Research has shown that plant growth is improved (15 to 20%) in greenhouses when CO_2 levels are increased to 800 to1300 PPM during the daytime. Tomatoes and

cucumbers grow best with 700-PPM CO_2. The most common method of adding CO_2 to the greenhouse is through the combustion of natural gas or propane. These fuels are burned in special units called CO_2 emitters. Information is available from greenhouse supply distributors.

Disease and Insect Control

Clean the entire greenhouse after the crop has been removed. The time spent will be paid back in time not spent spraying and in the cost of the chemical. Many producers also go through a second cleaning before the next crop if the growing area has been vacant for any time.

Rule No. 1: Clean your production area and keep it clean, even if the crop has been removed for the season.

Disease Prevention

- Some producers have a shoe bath when entering the growing area. This is to kill any pathogens that are on the soles of your shoes that have been picked up from outside or another growing range within the facility.
- TMV is a disease that affects tobacco and tomatoes and is devastating to a crop once it is infected. Ensure that people who smoke, wash and disinfect their hands before handling plant material. This is doubly important with role your own or pipe tobacco, because you are in direct contact with the leaves.
- Do not bring any outside plant material into the greenhouse.
- Reduce public traffic into the production area.
- Compost the greenhouse refuse in an area away from the greenhouse. There will be less chance of infestation from wind-borne spores.

Insect Prevention

- Screen vents to keep unwanted insects out of the greenhouse, remove alternate host plants from the greenhouse (weeds), limit bringing in outside plant material.
- Monitoring - scouting, records, sticky indicator cards.
- Chemical controls - must be registered for the crop and follow directions provided on the label, keep records and design a rotation of chemical families to limit resistance.
- Biological control - predatory insects used to control undesirable pests in the greenhouse.
- IPM (Integrated Pest Management) systems use predatory insects, hygiene and selective chemical control.
- Note: Biological systems have improved, they are easier to obtain and are available for most pests. There are some growers using no chemicals and they are able to control pest problems.
- Compost greenhouse refuse in an area away from the greenhouse. There will be less chance of pests from the compost process entering the greenhouse.

Weed Control

Weed control in the greenhouse is important because weeds are a host plant for disease and insects. It is important that weed control is continual and that the weeds are not allowed to reach seed production. The use of ground cover sheets will help reduce the need to chemically control weeds in the greenhouse.

The area around the greenhouse should be kept free of weeds. Trimmed grass and

weed free roadways are ideal greenhouse surroundings.

If and when using herbicides in a greenhouse, make sure that it is registered and that the label instructions are followed. In short: Do not use herbicides in the greenhouse.

Several producers have not followed the rate and or timing indicated on the label and experienced crop damage, where others have used unregistered herbicides and faced the choice of moving the entire greenhouse or digging out the greenhouse floor.

Scheduling

Scheduling of planting is an important function in greenhouse production. It requires knowledge of the time required for germination and the time from planting until first production. It is important to have the greenhouse producing to take advantage of high markets. In order to keep the greenhouse full, seeds must be planted so the young plants are maturing at the right time to be transplanted into the main greenhouse. Scheduling of planting is normally accomplished by counting backwards on a calendar.

Pruning and Training

Pruning involves making a series of decisions on the basic concepts of plant growth.

The main reasons for pruning plants are:

- to help recovery from injury to the roots,
- to remove dead or injured growth,
- to remove or restrict unwanted growth,
- to encourage or train growth where it is desired,
- to rejuvenate old plants,
- to promote flower and fruit production,
- to facilitate light penetration throughout the leaf canopy for more efficient use of light,
- to expose fruit to light when beneficial, and
- to increase air flow to reduce disease potential.

Pruning and training greenhouse plants creates conditions for maximum yield of high quality fruit by establishing and maintaining:

- optimum fruit load,
- complete leaf coverage, and
- uniform exposure of all foliage (for efficient light absorption).

Pruning and training methods for cucumbers and tomatoes are outlined later in this publication.

Controlling the Environment

Controlling the plant environment to target optimum plant growth accounts for approximately 90% of the plant's yield. In order to maximize yield and fruit quality, a grower must optimize the greenhouse environment. The key components of a plant growth environment are temperature, light, carbon dioxide, relative humidity, vapor pressure deficit, nutrition, irrigation and media. Each of these plant needs must be met in optimum balance in order to maximize plant yield and reduce stress.

Most modern greenhouses rely on controlling these plant needs with the aid of a computer. Climate computers have allowed more uniform control of these

variables as opposed to the on and off control of earlier mechanical systems.

There are three components in the regulation of an environmental factor. These are:

1. controllers
2. sensors
3. process equipment

The sensor measures the actual level of a given parameter (temperature, CO_2, RH) and gives the signal to the controller, which in turn determines whether the process equipment (ventilator, mixing valve, etc.) is to be activated.

Controllers

There are several types of controllers, which can perform functions, such as:

- turning a heater on when the temperature is too low and off when the temperature is too high;
- to open and close vents, depending on the temperature;
- to perform complex environmental control functions with consideration to inside and outside conditions; and
- microprocessor controllers can be used to control several functions at once, and keep records of the environmental conditions.

Sensors

There is a wide range of sensor technology that can be used in a greenhouse. These sensors range from the type that growers manually control such as household thermostats to computerized weather stations. The more money the more control appears to be the tradition.

Sensors can be used to identify changes in factors such as inside and outside temperatures, relative humidity, carbon dioxide levels, wind, wind direction, precipitation, pH, EC, time, sunrise/sunset, water and soil temperature, alarms, equipment and light.

Process Equipment

Process equipment is the electrical equipment that makes the changes necessary as indicated by the controller. This equipment includes ventilators, mixing valves, fans, carbon dioxide generators, dehumidifiers, solenoids, etc. An effective heating and cooling control system should be equipped with overrides and alarms. If a mechanical malfunction occurs the heating and cooling systems should have the capability of manual operation. Backup systems for heating and cooling are a necessity and should be automatically initiated or alarms should be activated if the temperature drops below a predetermined set point.

Alarm Systems

Alarm systems can be useful to let you know if any of the sensors in the greenhouse are outside the pre-set alarm parameters. For example, if the temperature becomes too cold or too hot, you could have an alarm ring in your office or home. Alarm systems can be run through wires or cables to other buildings or can be run through the telephone system in which case they can cause one or several telephones to ring. Alarm systems can alert the operator in the event that one of the many systems in the greenhouse has malfunctioned.

Reports

It is important to record the growing environment conditions and to evaluate production to identify changes that need to be made to improve profitability. It is common for most producers to record production yields, although it should not stop there. Why are yields up or down from last year? Why is the quality of the product different from last year? These questions can be answered by looking at records that show the environment, equipment, set points, alarms, "max/min/average temperatures," weather, light levels, and sunrise/sunset information. With this information the producer is able to make better decisions.

Building a Greenhouse

There are a number of decisions that need to be made before starting to build a greenhouse. In addition, as was mentioned earlier, checking regulations and obtaining the proper permits is very important.

Site Selection Considerations

Before deciding on a site for your greenhouse you should do a survey of the services available at that site and other factors which will affect the profitability of the greenhouse. You should consider factors such as:

1. Services available at the proposed site, including:

    - natural gas
    - single and three-phase power
    - suitable water supply
    - telephone

    It may be cheaper to locate the greenhouse where all of the required services are available than to pay for the development of a water supply or the cost of bringing in natural gas or electricity to your site.

2. The distance to market will affect your transportation costs. A good all weather road is an important asset.

3. Topography

    A level site with a slight grade to give good drainage will make construction easier and provide drainage. If your site is perfectly level, it may be necessary to haul in sand or gravel to elevate the area where the greenhouse is located. Another option would be drainage tiles.

4. Size of site

    The site should be large enough for future expansion. The layout of your greenhouse buildings depends on whether free standing or gutter connected houses are used.

Materials Used in Greenhouse Construction

Greenhouses are structures covered with a transparent material in order to grow plants. The main types of greenhouse construction are standalone or gutter-connect. The basic greenhouse construction material is either:

1. Glass
    - more expensive
    - high at light transmission
    - lower operating cost
    - glass has evolved from the early days of two feet by two feet glass panes to larger, stringer and lighter

sheets that can be curved if required. These new sheets are also more resistant to hail damage.

2. Polyethylene
   - It is the most widely used greenhouse film.
   - Six (6) mil greenhouse grade is commonly used.
   - It is tough, flexible and relatively inexpensive.
   - Single-layered polyethylene is seldom used due to condensation problems.
   - All of the greenhouses in the Saskatchewan Vegetable Greenhouse Survey used air-inflated double-layered polyethylene. Outside air should be used for inflation to prevent excessive condensation between the two layers.
   - It is important to match the size of the greenhouse to available widths of polyethylene sheets.
   - Whitewash can be painted on the outside of the polyethylene to a height of approximately 10 feet from the ground to stop the scorching of the fruit by the sun in mid summer. This practice should be looked at as a last resort because it does have a lasting impact on the polyethylene sheets.

Replacing the Greenhouse Polyethylene

The polyethylene on a greenhouse is usually replaced every three to four years. Six-mil **greenhouse** grade polyethylene is commonly used and replaced every three to four years. The cost to purchase two layers of polyethylene 48 feet by 150 feet is approximately $1700.00. To replace the polyethylene on a 30-foot by 144-foot greenhouse will take four or five people approximately three hours. Early morning is usually the best time to install new poly when there is no wind, because even a slight breeze can cause problems. It is also best to cover a greenhouse when the temperature is cool (ideal temperature would be 10 degrees C or 50 degrees F). This will allow the plastic to expand and contract without damaging the covering.

Capital Cost of a Greenhouse and Equipment

Greenhouse Construction Materials Cost

The following is an example of the cost of the materials for erecting a 30-foot by 144-foot freestanding greenhouse.

Freestanding greenhouse c/w arches on 4-foot centres, crossties on every second arch, wind braces, 5 runs of purlins, ground post, all hardware and setup instructions.		$6623.00
2 48' by 150' super Dura Film 4-6 mil	$864.00	$1,728.00
1 Inflation kit		$195.00
22 20' sections of wire lockit	$33.50	$737.00
2 48" exhaust fans with shutters	$1,697.00	$3,394.00
3 48" air intake shutters with motors	$492.00	$1,476.00
4 Horizontal air flow fans	$212.00	$848.00
1 Step 50A controller (takes the place of all thermostats)		$1,204.00
1 12' by 300' ground cover		$335.00
1 6' by 300' white poly		$175.00
1 3' by 3,000' white poly		$125.00
1 11 gal/min fertilizer injector		$448.00
310 Grow bags	$5.25	$1,627.50
2 Chapin tubing 2500' per roll	$89.50	$179.00
720 Spray stakes	$0.22	$158.40
Freight		$325.00
Subtotal		$19,617.90
GST @ 7%		$1,373.25
Total including GST		$20,991.15

Capital Cost of Other Greenhouse Equipment

The following are estimates of some of the other equipment that may be installed in a greenhouse or header house.

2 Furnaces 300,000 BTU natural gas installed	$7500.00
6 20-inch circular fans @ $133.00	$ 801.00
1 48-inch exhaust fan (1 hp)	$1140.00
1 36-inch exhaust fan (¾ hp)	$ 825.00
1 CO_2 burner	$ 600.00
Grow lights - 18 x 1000w @ $175.00	$3150.00
- 18 warm deluxe x 1000w @ $77.00	$1386.00
1000 ⅝-poly-tubing emitters @ $0.15	$ 150.00
5 42/40 grow trays @$104.00	$ 520.00
10 10/20 grow trays @ $1.15	$ 11.50
10 Hoods for trays @ $3.30	$ 33.00
2 Fertilizer injectors @ $600.00	$1200.00
2 1250 gallon poly water tanks @ $600.00	$1200.00
Homemade fan and pad cooling system	$ 555.00
1 Stand-by generator	$2000.00
Electrical system	$5000.00
Air conditioner for vegetable cold storage room	$ 300.00

Labour Requirements

The survey of Saskatchewan vegetable greenhouse producers calculated an average of 2027 square feet of greenhouse area per person year working in the greenhouse. The square feet per person per year varied in a range from 1730 square feet to 2500 square feet. This number was calculated by totaling all of the months of operator and hired labour used in the greenhouse, dividing by 12 months and dividing this number into the total square footage of the greenhouse. In other words, if your proposed greenhouse was 4320 square feet and you propose to operate 11 months of the year, you would need approximately (4320/2027) x (12months/11 months) = 2.3 people to operate the greenhouse. Depending on the crop and your individual operation the labour required could range from 1.8 to 2.7 person years.

One of the greenhouse operators compared a greenhouse operation to a dairy farm in terms of labour requirements. When you are in production, someone has to be there at all times. The only way the operator can take a day off is by training a replacement that knows the operation as well as the operator.

Greenhouse Vegetable Production Costs

In order to make a profit from your greenhouse you must perform the production, harvesting and marketing at a cost that can be covered by revenues. In order to achieve this goal you will have to continually monitor the profitability of the operation. Keeping accurate records of revenue, production, production techniques and costs will provide you with budgeting information that is required to make business decisions. One of the most important management functions is to develop a market for greenhouse production. In order to stay in business over the long term it will be necessary to achieve a market price that is profitable and competitive.

Greenhouse Vegetable Revenue and Cost of Production Survey

In December of 1998 and January of 1999 a survey of Saskatchewan greenhouse vegetable producers was conducted. The purpose of the survey was to collect information on the cost of growing greenhouse cucumbers and tomatoes in Saskatchewan. Of the producers surveyed some specialized in the growing of either cucumbers or tomatoes, others grew both cucumbers and tomatoes and others grew cucumbers, tomatoes, other vegetables and plants. The revenue and cost per square foot were calculated as an average of the revenue and cost of individual producers. The survey average of **total revenue** less the survey average **total operating expenses** is not equal to the survey average **return over operating expenses** because some of the data was excluded from the survey results.

The average total investment in buildings and equipment was $14.59 per square foot of greenhouse area. Of the investment in buildings and equipment approximately 32% of that or $4.67 per square foot was spent on buildings. Approximately 58% or $8.46 per square foot was spent on equipment. The balance of 10% was spent on vehicles. The total investment in buildings and equipment ranged from $8.73 to $18.55 per square foot.

One of the survey questions asked was "How many people work in the greenhouse and for how many months per year?" The total months of labour was divided by 12 to calculate the person years of labour used in the greenhouse. The total square feet of all greenhouses were divided by the total person years used in those greenhouses. The result was an average of 2027 square feet of greenhouse area per person year working in the greenhouse.

There were several adjustments required when compiling the data from the survey. It was difficult in some situations to merge accounting categories from several operations. Some operators had several enterprises such as cucumbers, tomatoes, bedding plants or herbs. It was difficult to separate expenses for each of the different enterprises because each of the greenhouse operators accounting systems is based on their total operation. The operations included in this survey were chosen because the returns and costs were mainly for the production of cucumbers and tomatoes. There were some operations where costs for bedding plant and/or herb expenses were included in the total expenses but these were minor in nature. Only 10% of the greenhouse square footage in the survey was used for growing crops other than cucumbers or tomatoes. When tabulating the survey results, the cucumber and tomato revenue per square foot was calculated

individually for each greenhouse operation and then averaged. The total revenue from all sources averaged $7.67 per square foot but ranged from $5.46 to $8.42 per square foot. The survey average expenses considered the total expenses for each operation in the survey. The average total operating expenses was $5.06 per square foot but ranged from $4.37 to $5.76 per square foot.

Table 1: Greenhouse Vegetable Survey 1998-1999 Results

	Average $/sq. ft.
Revenue	
Cucumbers	$8.53
Tomatoes	8.91
Total Revenue (including other revenue)	7.67*
Operating Expenses	
Production materials and supplies	
Seed	0.13
Grow media	0.25
Fertilizer	0.41
Plant protection, biological	0.09
Other, containers, labels, tags	0.13
Labour – hired	0.71
Greenhouse heating fuel	0.93
Electricity and water	0.36
Vehicle R&M, gas, reg. fees, lease	0.51
Greenhouse repairs and maintenance	0.37
Freight and express	0.04
Property and business taxes	0.00
Office supplies, telephone, accounting	0.13
Marketing and advertising	0.02
Travel, donations and membership	0.07
Small tools	0.06
Building and equipment insurance	0.17
Interest	0.61
Miscellaneous	0.03
Total Operating Expenses	$5.06*
Return Over Operating Expenses	$2.16*
Total Investment Building & Equipment	$14.59
Square foot per person year labour	2027 sq. ft.

* Sample average

Greenhouse Vegetable Production Fixed Costs

Based on the survey of vegetable greenhouse operators the average investment in land, buildings, equipment and vehicles was calculated to be $128,692. The breakdown of the total investment is shown in Table 2. Land value was assumed to be $500.00 per acre with two acres per greenhouse operation. The average area of vegetable greenhouse production in the survey was 8752 square feet.

Investment Cost

Investment cost is the cost of having your money tied up in an asset. Investment cost represents the interest that could have been earned on this capital if it had been invested elsewhere. Investment cost is calculated by multiplying the average asset value over its lifetime by the interest rate the money could be earning if it was invested elsewhere. The investment cost is calculated by averaging the original cash cost of the asset with the salvage value (usually 10% of the original cash cost) and multiplying that by the interest rate you could receive by investing your money. In this calculation an interest rate of 8% was used.

Annual Investment Cost

$$= \frac{\text{(Original Cash Cost + Salvage Value)}}{2} \times \text{(Interest Rate)}$$

Depreciation Cost

Depreciation represents the loss in the value of assets due to wear and tear and obsolescence. Depreciation is calculated by subtracting the Salvage Value of an asset (usually 10% of the Original Cash Cost) from the Original Cash Cost and dividing the by the useful life of the asset in years. The useful life of the asset is the estimated number of years until the asset is worth 10% of the Original Cash Cost. In these calculations the years of life used were buildings 30 years, equipment 15 years and vehicles 10 years.

Annual Depreciation Cost

$$= \frac{\text{(Original Cash Cost - Salvage Value)}}{\text{Years Life}}$$

Table 2: Investment, Depreciation Cost and Investment Cost Averages in Land, Buildings, Equipment and Vehicles for Vegetable Greenhouses Surveyed

Land value assumed (2 acres @ $500/acre)	$1,000
Land investment cost	$80
Average land investment cost per square foot	**$0.01**
Building area average square feet	8,752 sq. ft.
Building average value	$40,861
Building investment cost	$1,798
Building depreciation cost	$1,226
Average building investment cost per square foot	**$0.35**
Equipment average value	$74,061
Equipment investment cost	$3,259
Equipment depreciation cost	$4,444
Average equipment investment cost per square foot	**$0.88**
Vehicles average value	$12,770
Vehicle investment cost	$562
Vehicle depreciation cost	$1,149
Average vehicle interest cost and depreciation cost per square foot	**$0.20**
Average total investment ($)	**$128,692**
Average total investment cost per square foot	**$1.43**

Fixed costs must be covered if the business is to continue in production over the long term. An annual allowance must be included in the cost of production to replace the investment in buildings, equipment and vehicles as these items depreciate and need replacing.

Table 3: Operator's Return to Labour and Investment

	$/square foot
Average Total Revenue per square foot (survey average)	$7.67
Average Total Operating Expenses (survey average)	$5.06
Return Over Operating Expenses (survey average)	$2.16
Total Fixed Costs (investment and depreciation)	$1.43
Return to the Operator's Labour and Management (residual)	$0.73

Greenhouse Vegetable Production Return to the Operator's Labour and Management

When looking at the economics of any enterprise, the return to the operator's labour and management is often considered as a residual. In other words, everyone else gets paid first and what is left, after all of the operating expenses are paid and the fixed costs such as investment and depreciation cost are accounted for, is the return to the operator's labour and management. The return to operator's labour and management was calculated to be $0.73 per square foot

which works out to be $0.73 x 8752 square feet = $6,389.00 for the average size vegetable greenhouse in the survey.

Cucumber Management

Cucumber Management Rules of Thumb

- Seeding date to transplanting in greenhouse is approximately six weeks.
- Seeding date to first production is approximately eight weeks.
- Seeding date to first serious production is approximately nine weeks.
- It is important to take advantage of the high prices in the spring and fall.
- Cucumbers have a high labour requirement.
- Cucumbers have a high packaging cost.
- Cucumber training wires are generally 8 feet high.
- Cucumber production in the survey varied from 30 to 80 cucumbers per plant. The number of cucumbers required for your operation to earn a profit will depend on your cost of production.

Two Crop Cucumbers vs Three Crop Cucumbers per Year

Two crop cucumbers

- Harvest more cucumbers from a two-crop rotation.
- More quality problems.
- More labour is required because of increased pruning.

Three crop cucumbers

- Higher quality product.
- May get two to three more cucumbers per plant than two crop cucumbers.
- Less pruning because of younger plants.

Growing Media for Cucumbers

- Purchased media can consist of peat, vermiculite, wetting agent and dolomite.
- If you use 2.5 gallon pots, each plant gets 16 litres of uncompressed peat.
- 10-12 pots can be filled from a bag.
- The cost of peat mixture per cucumber is $1.25 to $1.60 depending on the price you pay for the peat mixture.

Two Crops per Year of Cucumbers Management Plan

The following dates are used for example purposes only to show the scheduling that must occur to maintain two or three crops of cucumbers per year in a greenhouse.

Crop 1

- Seed November 29.
- Transplant to main greenhouse on January 10.
- First production on January 24.
- Serious production starts January 31 (continues for approximately 18 weeks).
- Remove the crop from the greenhouse on June 6.
- Thorough cleaning and sweeping of the greenhouse.

Crop 2

- Seed April 26.
- Transplant to main greenhouse June 7.
- First production on January 21.
- Serious production starts June 28 (continues for approximately 20 weeks).
- Remove the crop from the greenhouse in mid to late November depending on the year, crop condition and growing conditions.

- Thorough cleaning, sweeping and disinfecting of the greenhouse.

Three Crops per Year of Cucumbers Management Plan

Crop 1

- Seed November 29.
- Transplant to main greenhouse on January 10.
- First production on January 24.
- Serious production starts January 31 (continues for approximately 13.5 weeks).
- Remove the crop from the greenhouse on June 6.
- Thorough cleaning and sweeping of the greenhouse.

Crop 2

- Seed March 26.
- Transplant to main greenhouse May 7.
- First production on May 21.
- Serious production starts May 28 (continues for approximately 10 weeks).
- Remove the crop from the greenhouse on August 4.
- Thorough cleaning and sweeping of the greenhouse.

Crop 3

- Seed July 7.
- Transplant to main greenhouse on August 18.
- First production on September 1.
- Serious production starts September 8 (continues for approximately 12 weeks).
- Remove the crop from the greenhouse in late November depending on the year, crop condition and growing conditions.
- Thorough cleaning, sweeping and disinfecting of the greenhouse.

Pollination

Commercial vine types are female and do not require pollination. Problems can arise if the greenhouse varieties are cross-pollinated (by bees) with field pickling cucumbers. Field-grown cucumbers have male and female plants and when greenhouse flowers are pollinated by field-grown cucumbers, they produce cucumbers that are bitter tasting and have seeds.

Pruning Cucumbers

Much of the information in this section was taken from the publication "Growing greenhouse seedless cucumbers in soil and soilless media." See this publication for more information on growing cucumbers.

Cucumber plants should be pruned to a single stem and supported by plastic twine. Place one end of the twine under the pot at planting time and attach the other end to an overhead wire supported 1.8 to 2.5 metres above the plant row. As the plant grows it winds around the twine. Remove side shoots or fruit or both according to the pruning and training system at least every week. As the plant becomes larger and carries a lot of fruit, use plastic snap on clips to attach it to the twine.

The main pruning systems practiced on greenhouse cucumbers are the original umbrella system and the modified umbrella system and their variations.

Original Umbrella System

To prune a plant according to the original umbrella system, follow these instructions.

Step 1
When the main stem reaches the horizontal wire (i.e., 2 to 2.5 metres high) pinch out the growing point allowing an extra two or three leaves above the wire. Use a small piece of string or a plastic clip to tie the main stem to the wire; the extra two or three leaves above the point of attachment will help the plant, when fully loaded with fruit, from slipping down.

Step 2
Remove all fruit and laterals from the lowest 60 centimetres of the main stem.

Step 3
Remove all fruit from the next 60 centimetres of the main stem but allow the laterals to grow to their first leaf and pinch them; allow one fruit to develop on each lateral.

Step 4
Allow one fruit and a lateral to grow from each leaf axil of the rest of the main stem; pinch the laterals after the second leaf and allow two fruit on each lateral (i.e., one in each leaf axil of the lateral).

Step 5
Allow the two strongest laterals from the top of the plant to grow over the horizontal wire and then hang down along the main stem; pinch these primary laterals when they grow one-half to two-thirds of the way down to the ground.

Step 6
Allow a secondary lateral from the axil of each leaf on the primary lateral to develop, pinch each secondary lateral after the second leaf and allow two fruit to develop on each secondary lateral.

Step 7
Remove any lateral if its fruit touches the ground.

Variations

1. In the first variation of the original umbrella pruning system, allow the main stem to grow along the horizontal wire (twisting it around the wire) and let it continue growing downwards as a "primary lateral." Then train a side shoot from a leaf axil at the top of the plant as a second "primary lateral" on the other side of the main stem.

2. In a second variation of the original umbrella pruning system, train the main stem along the horizontal wire until it reaches the next plant and then pinch its head. Then allow the two side shoots from leaf axils on the segment of the main stem trained along the horizontal wire to grow downwards in the usual way

Modified Umbrella System

To prune a plant according to the modified umbrella (stem fruit) system (Figure 2a), follow these instructions.

Step 1
When the main stem reaches the horizontal wire (2 to 2.5 metres high) pinch out the growing point allowing an extra two or three leaves above the wire. Use a small piece of string or a plastic clip to tie the main stem to the wire. The extra two or three leaves above the point of attachment will help prevent the plant from slipping down.

Step 2
Remove all fruit and laterals from the lowest 0.8 to 1.0 metres of the main stem.

Step 3
Continue removing all laterals, but allow one fruit to develop from each leaf axil of the rest of the main stem.

Step 4
Allow two laterals from the top of the plant to grow over the wire and then to grow down along the main stem (one on each side). Pinch the primary laterals before any fruit developing on them could touch the ground.

Step 5
Remove all side shoots from the primary laterals and allow only one fruit to develop at each leaf axil of the lateral.

Step 6
When the primary laterals get old and unproductive, allow new side shoots to develop at the top of the plant and repeat the cycle of steps 4 and 5. Before allowing new laterals to grow downwards, make sure they first grow over the horizontal wire for better support and light exposure.

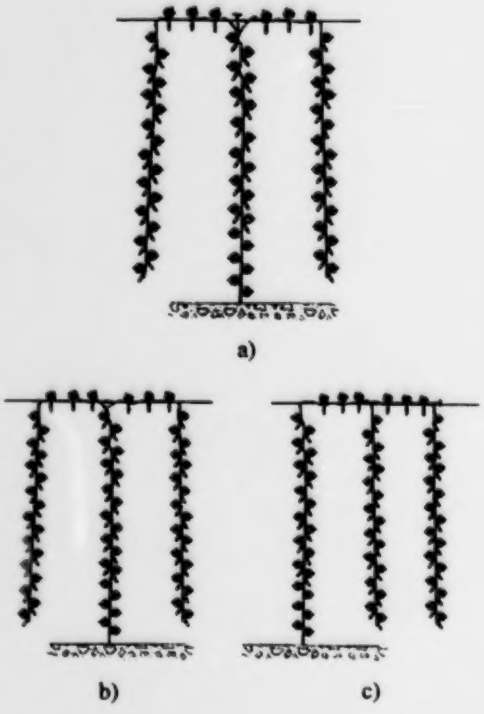
Variations

1. In the first variation to the modified umbrella (stem fruit) system (Figure 2b) allow the main stem to grow along the horizontal wire (twisting it around the wire) and then let it continue growing downwards as a "primary lateral." Then train a side shoot from a leaf axil at the top of the plant as a second "primary lateral" on the other side of the main stem.

2. In a second variation (Figure 2c), train the main stem along the horizontal wire until it reaches the next plant and then pinch its head. Then allow two side shoots from a leaf axil on the segment of the main stem trained along the horizontal wire to grow downwards in the usual way.

Figure 2: Modified Umbrella Pruning System

a) standard form
b) first variation
c) second variation



Training Cucumbers

Modern cucumber cultivars grown as greenhouse crops have retained the weak stems of their ancestors, so they require support when grown with a single vertical stem. The main cucumber training systems are the canopy system, the vertical cordon, the inclined cordon (V cordon) and the Guernsey arch.

Canopy System

Set plants to be trained according to the canopy system (Figure 3) in double rows 120 to 140 cm apart, with walking paths 180 to 200 cm wide separating the double rows. In-row plant spacing may vary from 40 to 60 cm depending on desirable planting density. Position horizontal support wires directly over the rows of plants, at a height of 2 to 2.5 metres (depending on the greenhouse structure and convenience, the higher the better). At the same height, extend a variable number of horizontal wires in the same direction as the rows over the walking paths to provide a convenient support and give form to the canopy.

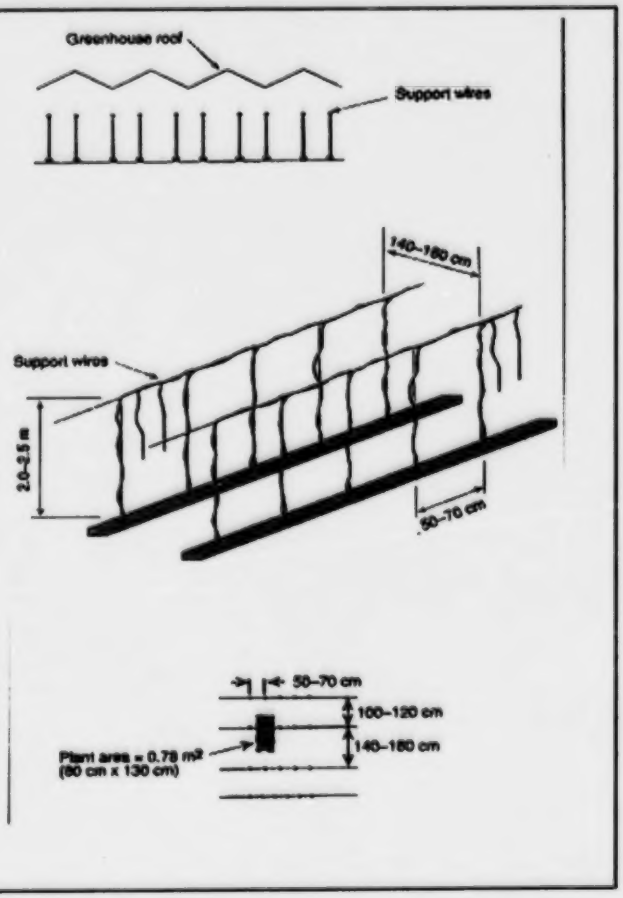
Train plants initially vertically along and around the support strings. When they reach the horizontal wires, train them horizontally over and across the walking paths.

Terminate the main stem, depending on in-row plant spacing, either half way across the path or after it runs the full width of the walking path. Prune these plants according to the modified umbrella system. However, train the primary laterals and any subsequent growth over the horizontal wires, rather than allowing them to grow vertically, and allow only the fruit to hang down. The constant need for training new growth over the wire to maintain the canopy, especially during the harvest period, is a serious disadvantage of this training system. The advantages are a smaller number of rows and therefore a substantial saving in growth media and labour and a potential for straight high quality fruit.

Vertical Cordon

Set plants to be trained according to the vertical cordon system (Figure 3) in double rows 100 to 120 cm apart with walking paths, 140 to 160 cm wide, separating the double rows. In-row spacing may vary 50 to 70 cm depending on desirable planting density. Position horizontal support wires directly over the rows of plants, at a height of 2 to 2.5 metres (depending on the greenhouse structure and convenience, the higher the better). Initially train each plant vertically along and around the support string and then along and around the horizontal wire until it reaches the next plant. Prune these plants according to the modified umbrella system, or under conditions of exceptionally good light and low cost for trained labour, according to the original umbrella system. The minimal plant support infrastructure needed and the systems simplicity make it the most attractive and popular training system. Research and practical experience in most parts of Canada indicate that this system may not always be the best for maximizing light absorption or the most productive. The vertical cordon training system has a definite advantage in producing high early yield, but its actual effect on final yield is still debated.

Figure 3: The Vertical Cordon Training System



Pest Control in Cucumbers

Western flower thrips has been the main pest. Bags of predator bugs can be purchased that will attack the adult thrips. The predators are specific to the pest. Information can be acquired from the predators' distributors.

Predatory mites can be used for the control of spider mites.

Ladybugs can be purchased to control infestations of aphids. Ladybugs come in boxes of 5000. If you are venting, you may lose 2500 of the ladybugs in the first day. However if the ladybugs lay their eggs, the larvae that hatch will eat the aphids. The larvae cannot fly so cannot get away.

Tomato Management

Tomato Management Rules of Thumb

- Tomatoes like forced air from the bottom of the plant.
- A ¾ horsepower jet fan with a 24-inch tube down the centre of the greenhouse near the top is useful for distributing CO_2 and removing excess humidity.
- Tomatoes like a daytime temperature of approximately 24 degrees C and nighttime temperature of approximately 18 degrees C.
- Tomatoes have a medium labour requirement.
- Tomatoes have a low packaging cost.
- Tomato training wires are generally 12-feet high.
- Tomato production, in the survey, varied from 14 to 30 pounds of tomatoes per plant. The number of pounds of tomatoes required for your operation to earn a profit will depend on your cost of production.
- It is possible to harvest upwards of 40+ pounds per plant. It depends on length of production time, light, nutrition and the overall health of the plants.

One Crop per Year Tomato Management Plan

The following dates are used for example purposes only to show the scheduling that must occur to maintain two or three crops of cucumbers per year in a greenhouse.

- Seed December 8.
- Takes about five days to germinate in warm propagation area.
- One week in 2-inch peat pots. Approximately 15% over planting.
- Transplant into six-inch peat pots.
- Apply artificial lighting to tomato seedlings.
- Transplant into either pots or grow bags in the main greenhouse on January 14.
- The advantage of pots is that when it comes time to lay the vines down you can turn the pots around to exert the least stress on the vine.
- The disadvantage of pots is there is more cleaning and disinfecting to do at year-end.
- First production will occur in late March.
- Remove tomato crop November 15 to December 20, depending on the year.
- Tomatoes can be up to a 13-month crop.
- Year end cleaning and disinfecting of the greenhouse walls, floor, pots, clips and other equipment with a 10% bleach solution. Some equipment like the plant suspension clips can be washed in an automatic washing machine using a bleach solution.

Pollination System

Once pollination has started, the day temperature should not fall below 18 degrees Celsius. For best results, pollinate between 11 a.m. and 3 p.m.. Greenhouse operators who manually assist pollination do so on a daily basis.

There are several methods of manually assisted pollination, such as:

- shaking the training wires by hand, and
- use of an electric vibrator on each of the flowering trusses.

Bumblebees are highly effective and widely used, although they require an educated operator in their requirements. For the correct pollination of 25,000 plants, you need about 60 bees and one queen and they

should last for about six to eight weeks. Pollination by bumblebees for smaller greenhouse operations, less than 10,000 square feet or less than 25,000 plants, may result in over pollination and the end results will be misshapen fruits.

Pruning and Training Systems for Tomatoes

Modern greenhouse tomato cultivars are bred for taste, vigor, disease resistance and yield. These tomato varieties are F1 hybrid (first generation seed) to ensure that these traits are kept strong. Greenhouse tomatoes are all indeterminate, meaning that the plant is still producing flowers when other tomatoes are ripening on the same plant.

Greenhouse tomatoes require support and are grown in a single vertical stem. Most growers use nylon bailer twine suspended from an overhead wire (6.5 to eight feet above the floor) to support the plants. There are commercial-made hangers that are designed to handle about 30 feet of twine, available from the greenhouse suppliers. As the plant reaches six feet, unwrap some of the twine from the hanger and lower the plant. Then slide it down the row one plant. This down and over means that part of the plant will start to cascade along the ground. When you hit the end of the row, go around to the other side of your double row. This also gives the plant another foot or so to grow before it reaches the six-foot mark again. The tomatoes (although not always) are already picked from the bottom of the plant and the leaves have been removed leaving nothing but the vine.

The plants need to be wrapped or clipped to the twine to give them the support required. Tie one end of the twine in a non-slip loop around the base of the plant. Make sure to give the stem some growing room in the loop. Care should be taken not to brake the plants or place the twine where it will affect the fruit truss.

Pruning has several aspects that should be looked at. The first will be to keep the plant growing in a single stem. Remove all side shoots or suckers at least once a week. The second is to prune the leaves off the bottom of the plant. This should start when the plants reach about four to five feet high and prune to expose (about) two clusters of fruit. This increases the air circulation, decreases disease potential and is said to help ripen the fruit quicker. For healthy plants try to always have at least 3.5 to four feet of leafed stem. The last pruning is when producers choose to reduce the number of tomatoes to increase the size of the tomatoes. Removing the bottom flowers of a truss does this; therefore leaving the top four or five flowers to produce larger tomatoes. It is variety and market specific if this management practice is beneficial.

Suggestions by Glen Sweetman

This last part is not fact or anything I care to prove. This is just what I find everyone knows after they have done it once. Although a few friends and myself have found out the hard way, there is always an easy and hard way to do things. Murphy's law says you will find the hard way first.

- Use sunscreen.

- If you are putting in a spaghetti irrigation system, put the spaghettis in right after you punch the holes for the spaghetti lines. The plastic has a memory and will close the hole somewhat. This is good because it helps seal the hole. It is really bad if you punch the holes and try to put the spaghettis in later. (This tip is only true for punches that do not remove a disk of plastic when the holes are made.)

- Check your pH and EC meters regularly before use.
  - They are very sensitive to slightly weak batteries.
  - Check the meters with buffer solutions. (Do not dip the probe into the stock solution, use a small clean container and then dispose of the contaminated solution.)

- Screening openings in the greenhouse is one way to keep greenhouse pests out and the good insects inside. Do not place fine screening directly over fans or vents. Most greenhouses and vents are designed for the correct airflow through the greenhouse. These screens reduce airflow considerably. If you are screening areas in the greenhouse, build a frame (box) around the opening or fan. This increases the surface area, which helps maintain airflow (availability).

- If winding twine around the plant for support rather than using the clips for vine support – always wrap clockwise! It tends to stunt the plant to wrap counter clockwise.

- UK rumor: Use clips for most of the production although if inter-nodes are long or fruit size is small, wrapping will slow the growth and increase fruit size.

- When building a 100-foot greenhouse why is it only 95-feet long? The plastic is cut at 100 feet and one needs a little extra to secure the ends.

- Be very careful to use registered herbicides for greenhouse use. There is a long list of chemicals that when used in the greenhouse will come back to haunt you. They produce toxic vapours that release slowly and build up in the greenhouse causing plant damage or loss. There have been several greenhouses that have had the choice of moving the greenhouse or digging down and removing a foot of soil throughout the greenhouse.

- Some growers acquire unique growing containers. Make sure they do not have anything in them that may cause damage to your crop. Plastic can slightly bond with unwanted chemicals, so find out what was in them because a few washes may not be enough.

- If using HID lights to extend the light, do not use bees for pollination. The bees

are attracted to the HID light and bang themselves up, especially if it is the sole source of UV. In most cases, growers already using bees will keep the bees rather than turning the lights on. You will have to choose increased pollination or the increased plant growth. In short, do not use lights with bees.

- Bees within UV blocked poly greenhouses are attracted to open vents because it is a source of UV light.

- When pruning, it is easier to prune the bottom of the plant of all the plants. Then when one is lowering the plant, remove the lateral top growth, wrap or clip the plant and then slide it over.

- Dew or free water on the leaves is an ideal growing condition for diseases and should be avoided whenever possible.

- When putting in irrigation systems,
  - flush the lines to remove "junk" that has entered the system before capping the ends, and
  - check water pressure compatibility before installing a watering system.

- Although it sounds hard, it is actually easy to set up your systems with enough check valves that one can work on almost any part and still get water to your crop. A few elbow and check valves will save time and money later.

- Make sure that there is a back flow valve stopping the greenhouse water from draining back down the line into the water source (well, etc.). It may even be the law...

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